<u>Co-operation is the key - PLANT SUCCESSION:</u>

Plant succession is another fundamental principal of landscape function that is very misunderstood by mainstream scientist. Plants are the key to managing everything from the climate, to in ground and surface water systems, as well as animal bio-diversity and soil health. Working with Plants and their natural succession process is fundamental to landscape restoration.

Nature is a self-repairing system that naturally moves towards equilibrium. The current problem is that we have vastly increased the amount of energy entering the system, disrupting the feedback loop network, and driving the cycles away from equilibrium.

Everything is energy:

Inputs of all kinds constitute an energy source. Whenever we create order in a system it requires the input of energy. Equilibrium is maximum disorder and all systems move towards order when there is an energy imbalance. For a system to find balance again it must re-establish a high degree of disorder.

When we look at the environment, what constitutes disorder? Bio- Diversity creates disorder. The higher the level of diversity the greater the disorder. The function within the disorder is that complexity allows energy to flow unrestricted to the entire biota.

Pictures show a stark contrast between a natural disordered system (above left) and an ordered farming system. (above right). ***Image creator dan***

How can we work with the natural process of systems moving towards equilibrium? We must firstly reduce our energy inputs entering the systems. Our human footprint is very heavy and we need to begin treading lightly on the earth. Many of these issues can be effectively addressed through holistic approaches to "Ecologically Sustainable Development".

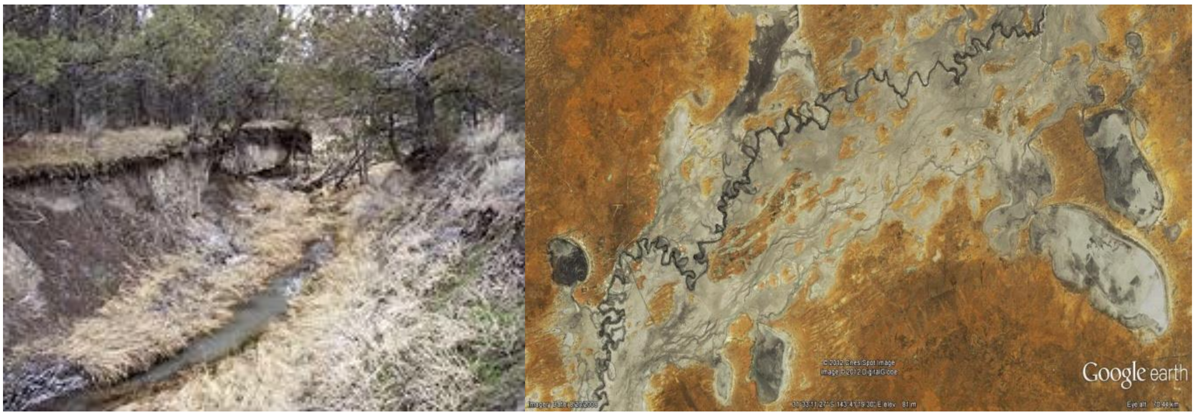
Farming is perhaps the single most destructive practice we carry out. Current methods require the removal of all bio-diversity over large areas of land, to create an ordered system (monoculture). The resulting loss of fertility and increasing pest and disease problems have lead to the increasing use of chemical inputs. This input of excess energy then devastates the soil chemistry and biology further, creating more pestilence and plague.

Irrigation and storm water runoff from farmlands poison our water systems with excessive salts/nutrients and chemicals, wiping out much of the diversity within our rivers and streams. Tilling the ground destroys soil structure and leads to the loss of organic matter; this intern leads to the further loss of fertility and the loss of our top soils.

Excessive plant nutrients, fertilizers, entering our water bodies cause algae blooms to chock our rivers, lakes and billabongs (top left). The tilling of our soils destroy the soil structure allowing top soils to erode and also wash into our water bodies (top right). This process is called eutrophication and leads to low oxygen conditions and the decimation of our aquatic environments.

With vastly reduces vegetation cover, flooding rains become destructive, and scour deep channels in our hills and flood plains. Once the flooding has past, these channels left behind act like a drainage system carrying all of our water to the ocean, and in the process draining the landscape of its precious ground tables.

Modern farming practices have input massive amounts of energy into the natural system, resulting in the destruction of the landscape functions and the desertification of much of our once fertile lands



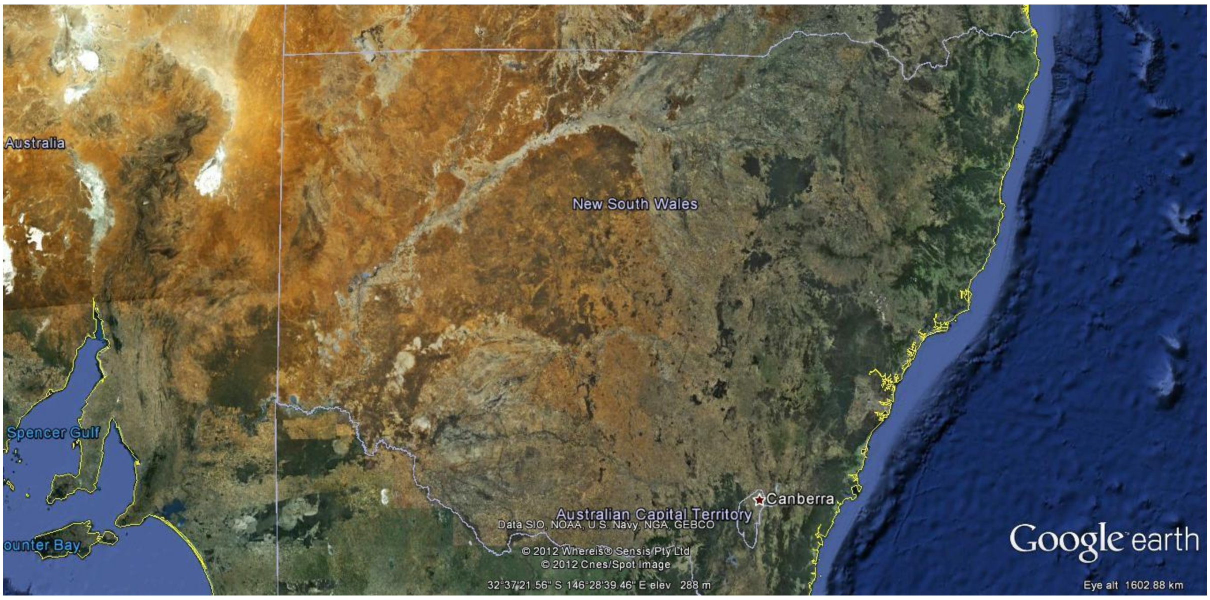
Channels form on the edge of floodplains and along river flow lines (top left). An aerial shot of the Darling River showing the eroded river channel crisscrossing the flood plain (top right). This draining of the floodplain ground table causes the desertification of the landscape. You can still see the old flow lines and billabongs that are now dry (top right).

I will look at farming in a future paper, but keep in mind every landscape function you are learning about here needs to be incorporated into the management system of any farm. Let's just focus on regenerating natural systems for the moment.

NATURAL AREA RESTORATION USING PLANT SUCCESSION

Arguably the largest energy increase mans impact has created is the input of solar radiation. We have cleared much of the landscape and have vastly increased the suns intensity reaching our soils. Where before the plants insulated the landscape, and shaded the soils, the sun now bakes them dry and heats the air above them. Between the ultra violet light and the lack of moisture, the soil diversity is decimated.

If diversity decreases within the soil then energy can no longer flow unrestricted to the plants. The result of infertile soils is an energy imbalance causing plant communities, the first trophic level, to move away from equilibrium, impacting on all trophic levels above them. If the landscape functions have broken down and there is no secondary feedback loops functioning, then the end result could be a desert.



We have cleared much of the Murray Darling Basin creating a massive man mad desert throughout much of NSW (above).

So how do we get plant communities to begin their natural succession process back towards equilibrium? We begin by reducing the amount of solar energy entering the system. This can be done using a combination of rehydrating the landscape and layering. I will cover rehydrating the landscape in the next section, but for now I will focus on using plant successions to develop layering.

There is a natural succession process that plant communities cycle through. When soils are impacted by high energy inputs such as wind and sun, this evaporates soil moisture and decreases fertility. Areas such as exposed ridges, sand dunes and headlands, and further afield the semi-arid zones are all dominated by heath scrub (shrub lands) and or dry grassland communities. If water availability drops, these systems become deserts.


Dry grassland (top left). Heath scrub (top right)

As we have drained the landscape and baked it dry in the sun, heath communities and other dry plant communities, such as woodlands and dry forests have greatly expanded their territories. Much of what was wetlands, rainforest and wet forests have become dry forests and even woodlands. Our impact on the environment has driven the plant succession process away from equilibrium, towards desertification, and in the process has enabled fire to rampage out of control.


Dry woodland (top left). Dry forest (top right) with fire rampaging out of control due to the domination of dry plant communities (top right).

At the other end of the scale are the wet forests and rainforests, plant communities that can only dominate in ideal conditions with optimum water availability and fertility. In these conditions maximum bio-diversity within the soil can develop, allowing energy to flow unrestricted between the trophic layers of the plants and soil biota. This allows maximum diversity to also develop within the plant community. If water availability increases further, then a wet grassland / wetland system will result.


Rainforest (top left). Wetland (top right)

The natural plant succession from the least fertile, driest soils, to the most fertile, moist soils, is 1- HEATH SCRUB / DRY GRASSLANDS: Single layered systems, least bio-diversity, highest number of repair plants, 2- WOODLANDS: two layered systems, 3- DRY FORESTS: Three layered systems, 4- WET FORESTS: four layered system, 5- RAINFORESTS: five layered systems, most bio-diversity, lowest number of repair plants.

All these plant communities exist in different microclimates throughout the central coast. Our temperate climate, unique geological features and proximity to the ocean create dramatic variations in the amount of available water in our soils. Exposure to wind, aspect, degree of slope, height on slope and distance from the ocean are all determining factors in creating our microclimates. The result is a mosaic patch work of different plant communities, giving the central coast region one of the highest levels of diversity left in the country. This makes our region one of high priority when it comes to diversity protection.

WONDEFRULL WEEDS

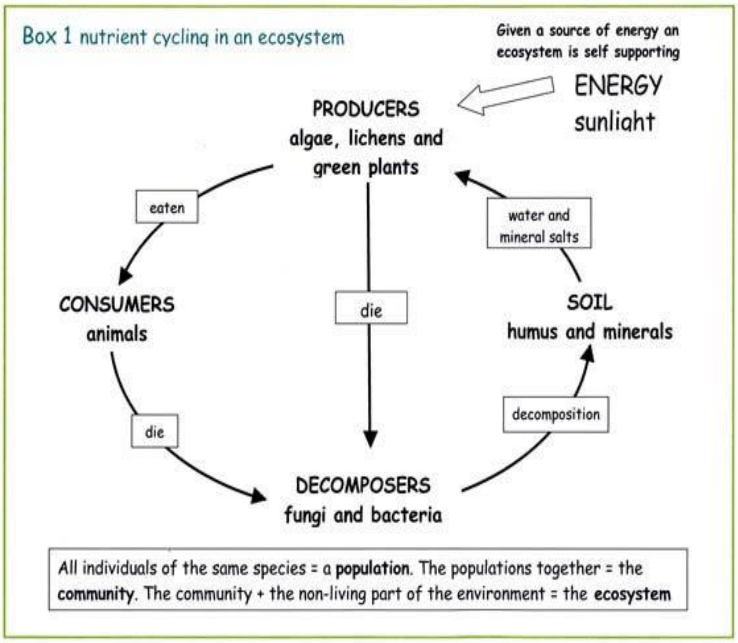
Weeds can encroach into any of the succession stages, but only if there has been a disturbance in the layers of the system. Weeds are categorised as primary succession plants and are the first repair plants to re-establish in a disturbed ecosystem. They are the secondary feedback loop that absorbs some of the excess available energy, increased sun intensity, and converts it into bio-mass. It is this efficient conversion of solar energy into chemical energy that gives weeds their ability to quickly re-build soil fertility.

Primary succession plants are opportunist, fast growing ,short lived and have effective distribution mechanism that allow them to spread quickly. They will also have specialised root systems and other adaptation that enable them to grow well in poor conditions. Their function is to cover the soil quickly by creating a layer of vegetation, reducing sun intensity, trapping humidity and allowing soil moisture and fertility to begin to rebuild.

The weed, morning glory, attempting to enclose the dry forest edge and develop a closed canopy (above). This will create conditions suitable for plant succession to occur and a wet forest or rain forest to develop.

An equation Peter Andrews taught me in order to determine the effectiveness of a repair plant, is to calculate the green surface area over time and space. In other words the green surface area of the plant is- divided by-(the time the plant takes to mature- times- the space the plant takes up at ground level). The weed that has the largest green surface area, grows the quickest and takes up the least amount of space will be the most effective repair plant.

The large green surface area can convert more of the suns energy into bio-mass. The short life cycle means that the plant can quickly pass on that bio-mass to the soil biota, when it dies and decomposes. This enables the soil biology to more quickly rebuild in diversity, and repair the soil structure. The smaller the area the plant takes up at the soil surface the greater the number of plants can grow in any one place and the more effective the repair process becomes.



The Field study Council

By observing weeds we can come to understand the natural repair process that plants facilitate in the landscape. Developing layers of vegetation quickly, using specialised repair plants. At no point within natural cycles are any plants removed from the system until their function has been completed.

We need to recognise that weeds are not the problem and in fact are part of the solution. They are simply the repair mechanisms, the secondary feedback loop, which has been initiated by our impact on the landscape. Where ever human impact contributes a high energy input into an ecosystem the weed succession will simply continue to dominate in a desperate attempt to correct the imbalance.

Landscape repair will only become effective when we begin co-operating with the weeds. This will allow the network of secondary feedback loops to begin to re-establish and initiate the natural plant succession process back towards layering and diversity.

As the soil moisture and fertility increases, due to the weeds, the plant community above begins to increase in both layering and diversity. As the layering and diversity increases within the plant community, the soil biota below increases in both layering and diversity. If the microclimate is suitable, this feedback loop will drive the plant succession all the way back to a rainforest.

So vegetation layering is one of the keys to landscape function. It reduces the amount of solar radiation entering the system, by shading and insulating the soil. It converts much of the excess available solar energy into bio-mass for distribution throughout the food web. It traps lost soil moisture as humidity within the layers of vegetation, which in the cool of the evening condenses and returns to the soil (micro water cycle). As well, it helps build soil structure and protects the soil from erosion.

However, probably the most important function of vegetation is its moderation of the climate. Plants are not only responsible for filtering CO_2 out of the atmosphere, they also manage the hydrological systems on land and are influential in developing and maintaining both in ground and surface water systems. The transpiration of water from their leaves provides moist air above the landscape allowing low pressure systems to be drawn in off the ocean, bringing more regular and less extreme rain events to the inland.

I will discuss these last two points in more detail in the next section, as I am going to explain the most important landscape function of all, the hydrological system. This is what I have learnt most about from Peter Andrews. The process of rehydrating the landscape is the key to both landscape repair and sustainable farming practices, and because of this I can't really go into any more details on either point until you understand more about water.

Written by

Ian Sutton

Understanding the situation - BIO-DIVERSITY:

Have you ever wondered why bio-diversity within the Environment is so important? It all comes down to the complexity of feedback loops, all interacting with each other. In order for equilibrium (perfect balance) to be maintained within a system there must be a zero energy input, an equal flow of energy both entering the system and leaving the system. This flow of energy creates cycles, or feedback loops, within the system.

When there is an excess of energy either entering a system, positive input, or leaving a system, negative input, the balance will move away from equilibrium. As this energy imbalance is corrected the system will begin moving back towards equilibrium. Individual cycles or feedback loops within the system will automatically absorb or release energy as needed, to maintain the overall energy balance.

As excess energy is absorbed, the individual feedback loops will themselves move away from equilibrium. Once this excess energy is consumed it will then be released again as the cycle returns to equilibrium. This release of energy is then made available for other feedback loops to absorb and move away from equilibrium, and intern passing the energy on when they return to equilibrium.

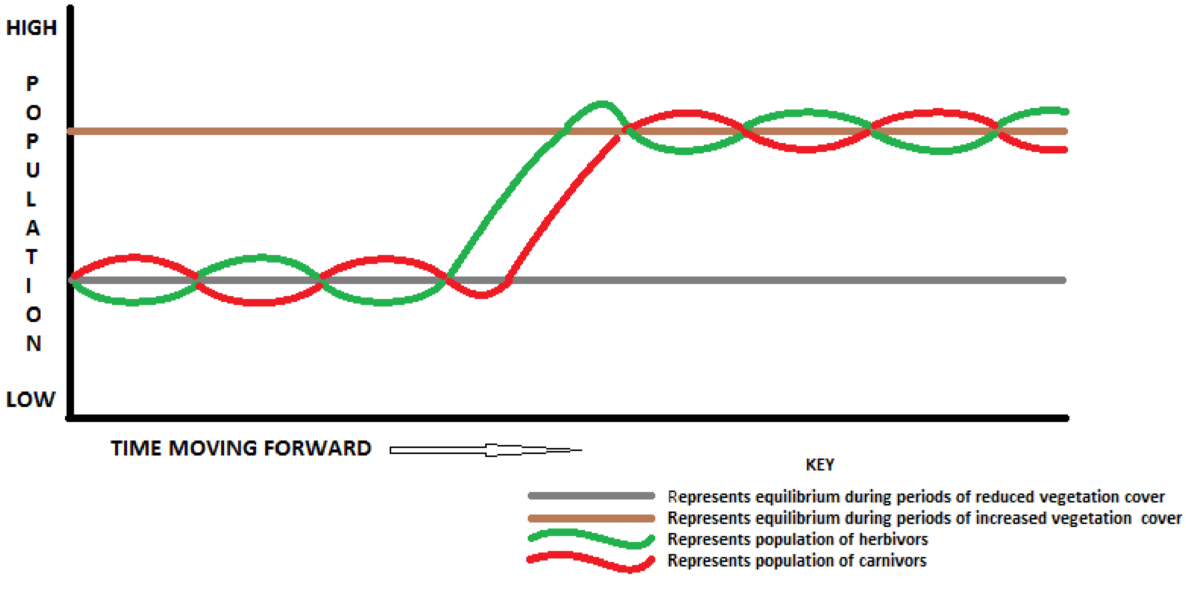
The greater the number of feedback loops all interacting with each other; the less energy is available to any one loop. Complexity and disorder is what safe guards against any one cycle absorbing to much of the available energy and moving to far away from equilibrium.

THE FOOD WEB:

One simple example of a feedback loop system is the food web, the predator prey relationships. This is the cycle of solar energy that is converted into chemical energy by the plants and some microbes. The food web facilitates the flow of this energy throughout the entire biota (all living things).

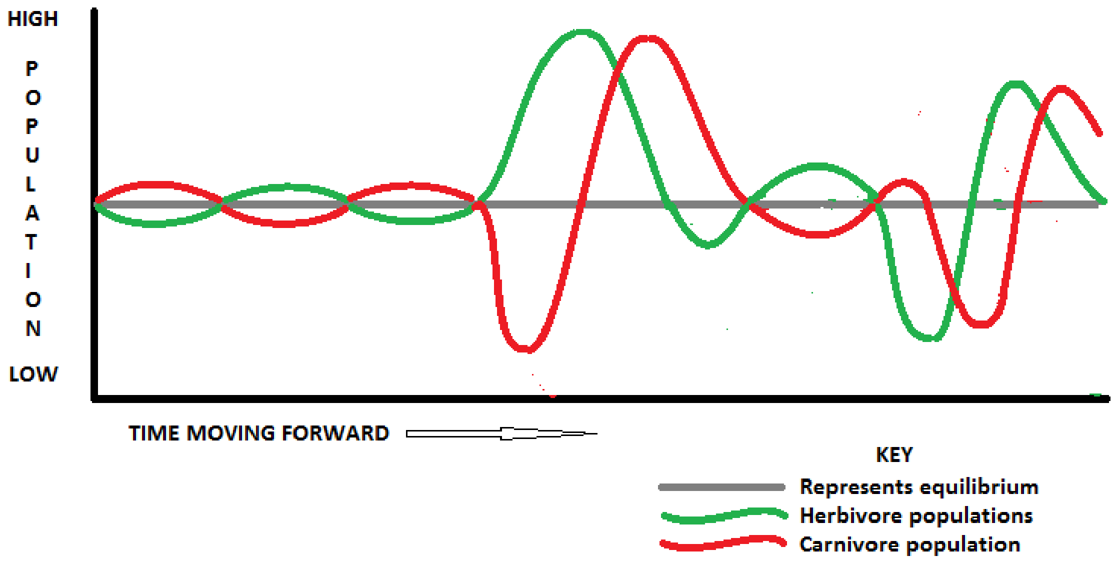
EXAMPLE:
If a wallaby population increases in number it can be due to the influence of several feedback loops. If it is a good year for rain, extra energy entering the system, the increased growth of vegetation will provide a higher Kilojoules intake for the wallabies. The response to this increase in available energy is an increase in Wallaby population and a shift away from the existing equilibrium. Alternatively, it could be a sudden decline in predator populations due to human impact, this also equates to an energy input to the wallabies, again responding by increasing in population.

Graph depicting fluctuations in populations of both the preditors and prey within a balanced ecosystem with high bio-diversity, aswell showing the shift to a new equilibrium when vegetation increases as a rersult of extended periods of wet wheather.



In situation one the growth of the population of wallabies, due to increased vegetation growth, will slow and then cease when the population of the predators also increase, as a response to their increasing food supply, creating a new equilibrium.

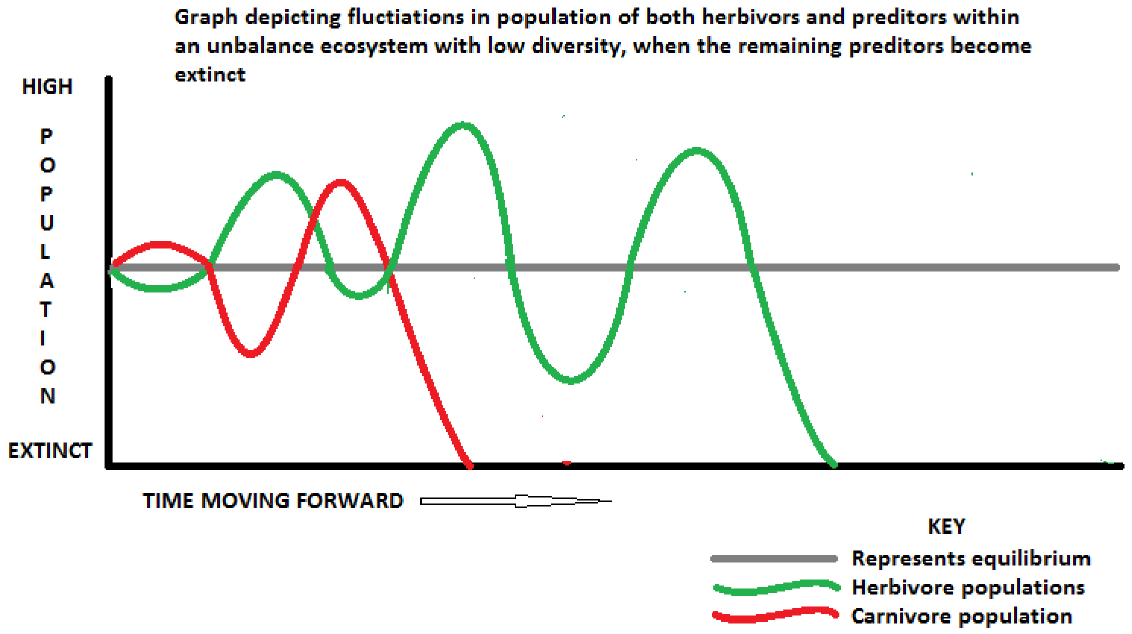
Graph depicting fluctiations in population of both herbivors and preditors within an unbalance ecosystem with low diversity,



Alternatively, as in situation 2, if there is a sudden decline in predator populations, the wallaby population increase will only slow and then cease once their available food source (vegetation) declines and there is not sufficient energy input to continue their population growth. As the predator populations recover, the energy is shared and the balance returns. However, with low bio-diversity comes only a temporary balance with regular erratic population fluctuations. A steep incline in population growth is always followed by a steep decline.

A simple food chain is a connection of feedback loops. From each successive feedback loop energy moves through the food chain. A complex food web is a network of feedback loops all interacting and mediating each other. As bio-diversity decreases, strands of the food web are cut. As the complexity of the food web decreases the buffering effect is decreased and individual feedback loops can now absorb much larger inputs of energy.

If there is low bio-diversity within a food web, human impact or climatic extremes can have dramatic effects on population fluctuations and can easily result in the loss of more species. If an event such as drought triggers the local extinction of the last of the wallabies predators, their own population increase would not be mediated The Wallaby plague would only begin to decrease in population when the energy the vegetation is providing decreases through over grazing. However this secondary feedback loop does not kick in until after the damage is done and can lead to desertification and extinction.



The greater the numbers of relationships an organism has, the more safeguards are in place. If an organism has many predators and one becomes extinct, the resulting available energy would be shared by all related feedback loops allowing all the populations to increase only a small amount. The population of the prey will still be maintained by the other existing predators, as all population then adjust towards the new equilibrium.

TROPHIC LEVELS:

The food web is also layered into trophic levels. Each level is influential in balancing the levels below and above them. The highest trophic level is the top predators. Top predators (carnivores) tend to be opportunist hunters who have a wide range of prey, both primary consumers (herbivores) and secondary consumers (omnivores and scavengers).

Like with all living organism, energy efficiency is the name of the game, so top predators hunt whatever is easiest to catch. If any of their prey has a spike in population, they become the easiest to find. The top predators act as a secondary feedback loop to correct any energy imbalances within the trophic layers below them. Very important function!

Diagram depicting the trophic layers within a simple food chain.

The Environment is a network of relationships and the greater the bio-diversity, the more complex the network becomes and the more balanced the system remains. High bio- diversity mediates the populations of all living things and as diversity decreases the fluctuation in populations increase. Pest and disease are the results of a decrease in bio- diversity while pestilence and plague are the results of the loss of bio-diversity.

Australia is losing species at an alarming rate and once the level of bio-diversity reaches critical point, the stage is set for a mass extinction. Combine this with climate change predictions of more extreme weather patterns creating prolonged droughts and then destructive flooding rains, and the near future does not look bright for our flora and fauna.

We need to protect all remaining diversity if we are going to have any chance of restoring a balance to the environment. Keep in mind, if the mass extinction does occur, we won't see a balance return until new bio-diversity evolves. That is only a split second in geological time but will seem forever in human time.